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Simulation of an Interline Dynamic Voltage Restoring and Displacement Factor Controlling Device (IVDFC)

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ABSTRACT: An interline dynamic voltage restorer (IDVR) is invariably employed in distribution systems to mitigate voltage sag/swell problems. An IDVR merely consists of several dynamic voltage restorers (DVRs) sharing a common dc link connecting independent feeders to secure electric power to critical loads. While one of the DVRs compensates for the local voltage sag in its feeder, the other DVRs replenish the common dc-link voltage. For normal voltage levels, the DVRs should be bypassed. Instead of bypassing the DVRs in normal conditions, this paper proposes operating the DVRs, if needed, to improve the displacement factor (DF) of one of the involved feeders. DF improvement can be achieved via active and reactive power exchange (PQ sharing) between different feeders. To successfully apply this concept, several constraints are addressed throughout the paper. Simulation results elucidate and substantiate the proposed concept

I. INTRODUCTION

In this Project, a Cascaded H-Bridge Multilevel Inverter (MLI) based Interline Dynamic Voltage Restorer (IDVR) is proposed for Voltage Sag/Swell Compensation and Harmonic Suppression in Distribution Network. In Distribution System, mitigation of odd order harmonics are needed to improve the performance of power distribution to sensitive loads. [1] But in IDVR the generated harmonics are not eliminated completely by Voltage Source Converters (VSC) with Active Filters (AF).Therefore, instead of using VSC, the Cascaded H-Bridge MLI topology based IDVR is proposed to compensate voltage sag/swell as well as to suppress the harmonics.DISTRIBUTION networks are mostly inductive at the fundamental frequency because of the nature of the dominant connected loads (e.g., induction motors). This, in turn, reduces the displacement factor (DF) and places an additional burden on the electrical supply. LowDF operation is not recommended due to several negative effects on the power system including: 1) higher current for a given active power and a corresponding increase in total copper loss (i.e., system efficiency decrease); 2) lower utilization of power system components; 3) voltage regulation issues and rising power delivery costs. Several practical techniques are commonly used to improve DF . DF improvement employing capacitor banks with size and location optimization has been introduced in . The optimal location and size of the capacitor bank to be placed in radial distribution feeders to improve their voltage profile and to reduce the total energy loss are presented in . Different techniques are employed in to minimize the power loss in distribution networks. In [2], the feeder reconfiguration concept in distribution systems is introduced to reduce system loss. In , a combined system for harmonic suppression and reactive power compensation is proposed not only to improve the DF but also the power factor. A Statcom can be used as a viable alternative for DF improvement. Suitable adjustment of the phase and magnitude of the STATCOM output voltages enable effective control of active as well as reactive power exchanges between the STATCOM and the distribution system. [3]Such a configuration allows the device to absorb or generate controllable active and reactive powers. A STATCOM has various features, including fast response, low-space requirement, and good stability margins.[4] Recently, it is rapidly replacing the conventional naturally commutated reactive power controllers and static VAR compensators the reactive power supplied by the STATCOM for DF improvement is capacitive in nature. Intuitively, the higher the STATCOM's reactive power, the higher the dc-link voltage of the STATCOM (the higher

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the voltage requirements of the semiconductor devices). The DVR is one of the most common and effective solutions for protecting critical loads against voltage sags. The DVR is a power electronic device used to inject three-phase voltages in series and in synchronism with the distribution feeder voltages in order to compensate for voltage sags. Moreover, it can be effectively used to enhance the fault ride through capability in wind applications.[5-7] Detection time is an important factor in the voltage restoration process. Fast detection algorithms and effective control schemes for a DVR are proposed in [8] and [9], respectively. Space vector modulation (SVM) is the recommended modulation scheme in a DVR due to its simple digital realization and improved dc-link utilization [10]. In distribution systems, load voltage restoration can be achieved by injecting active and/or reactive power into the distribution feeder. Active power capability of the DVR is governed by the capacity of the energy storage element and the employed compensation technique [11]. Several control techniques have been proposed for voltage sag compensation, such as presag, in-phase, and minimal energy control approaches [12]. If the required power for voltage restoration is obtained from the neighboring feeder(s), the compensating device is technically called an interline dynamic voltage restorer (IDVR) [13]. The basic concept behind the IDVR is derived from the interline power flow controller (IPFC) proposed by Gyugyi in 1999 [14] to exchange power between parallel transmission lines.

II. PROPOSED SYSTEM - BLOCK DIAGRAM

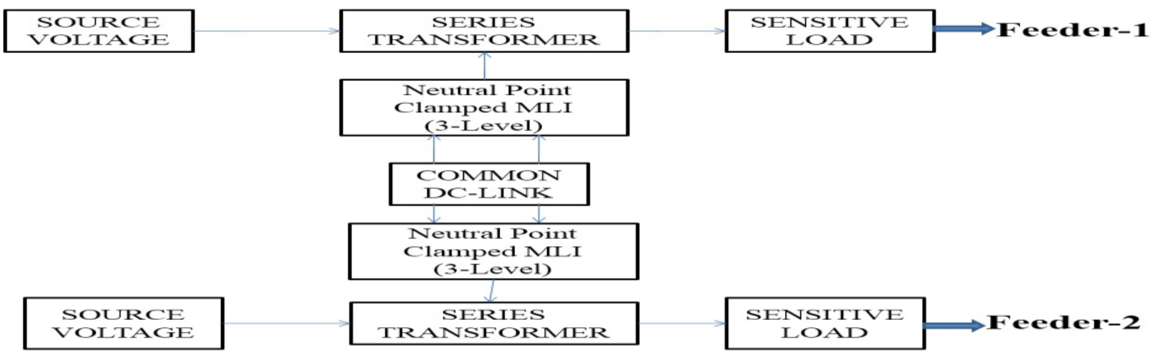

Figure 1 Block diagram

Description:

- The Neutral Point Clamped MLI is also Known as Diode Clamped MLI.
- The NPC Inverter (or) the Diode Clamped MLI topology based IDVR is proposed to compensate voltage sag/swell and also to suppress the odd order harmonics .
- It can be employed in normal as well as in abnormal conditions in distribution system.

Dc link

A DC link exists between a rectifier and an inverter, for example, in a VFD or phase converter. On one end, the utility connection is rectified into a high voltage DC. On the other end, that DC is switched to generate a new AC power waveform. It's a link because it connects the input and output stages.

The term "DC link" is also used to describe the decoupling capacitor in the DC link. I assume that this is what you're asking about. The switching network on the output side generates very large transients at the switching frequency. The DC link capacitor helps to keep these transients from radiating back to the input. This can also help prevent the switching network from oscillating or triggering inadvertently at an inappropriate moment and causing a short. Additionally, if the input is not multiple-phase, the capacitor helps provide a source of energy when the input waveform is near zero.[15]

Neutral Point Clamped (NPC) inverter

The three level inverter offers several advantages over the more common two level inverter. As compared to two level inverters, three level inverters have smaller output voltage steps that mitigate motor issues due to long power cables between the inverter and the motor. These issues include surge voltages and rate of voltage rise at the motor terminals and motor shaft bearing currents. In addition, the cleaner output waveform provides an effective switching frequency

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twice that of the actual switching frequency. Should an output filter be required, the components will be smaller and less costly than for an equivalent rated two level inverter. Most often the NPC inverter is used for higher voltage inverters. Because the IGBTs are only subjected to half of the bus voltage, lower voltage IGBT modules can be used. Powerex's TLI series of IGBT modules provides a cost effective way to bring the advantages of this topology to 460V applications. For more detailed information please refer to the datasheets located on the Powerex web site. Basic Circuit Configuration and Its Behavior Figure 1 shows the circuit configuration of the NPC inverter. Each leg has four IGBTs connected in series. The applied voltage on the IGBT is one-half that of the conventional two level inverter. The bus voltage is split in two by the connection of equal series connected bus capacitors. Each leg is completed by the addition of two clamp diodes.

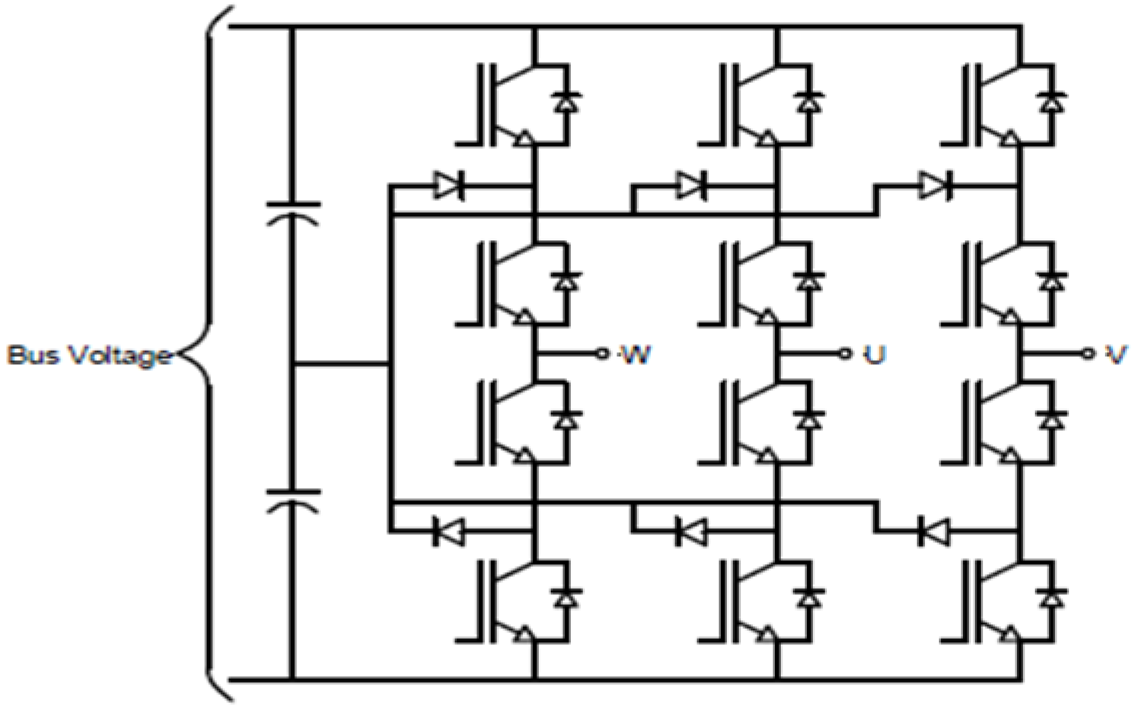

Figure 2 NPC inverter

This topology traditionally has been used for medium voltage drives both in industrial and other applications. In addition to the capability of handling higher voltages, the NPC inverter has several favorable features including lower line-to-line and common-mode voltage steps and lower output current ripple for the same switching frequency as that used in a two level inverter.

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III. SIMULATION ANALYSIS

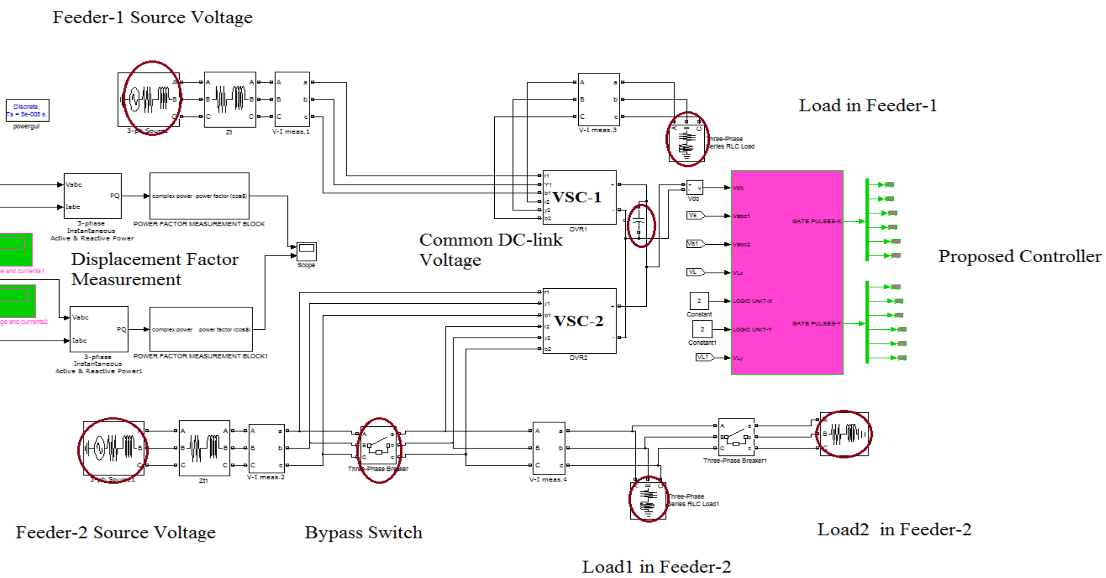
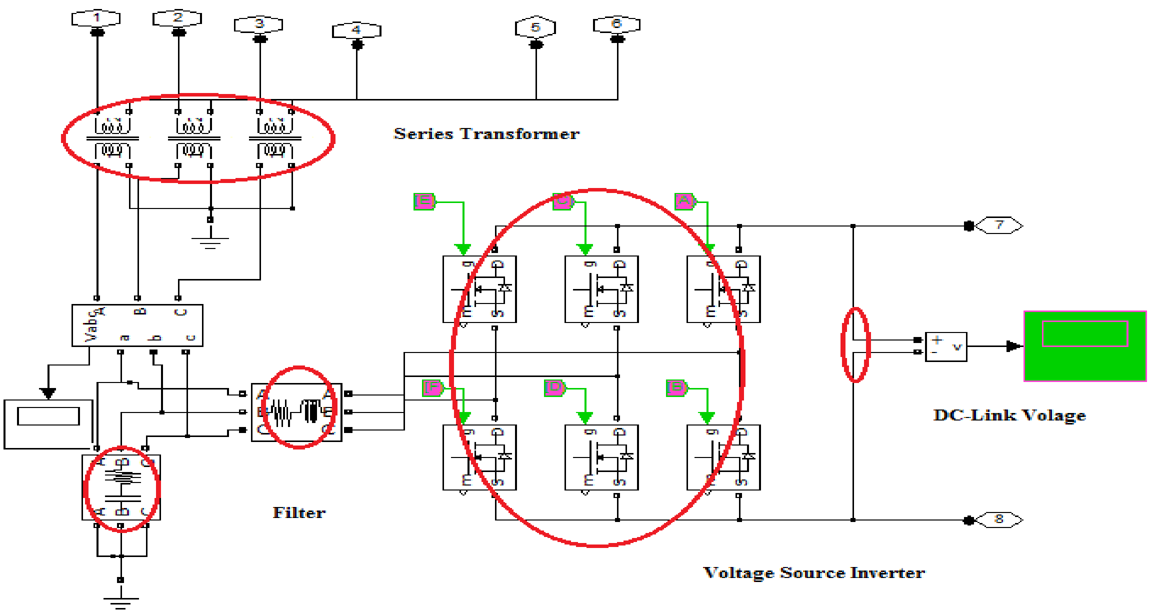


Figure 3 Simulation Circuit of an -IDVR

DVR(Subsystem)-Voltage Source Converter
Source Voltage & Current Waveform for an -IDVR



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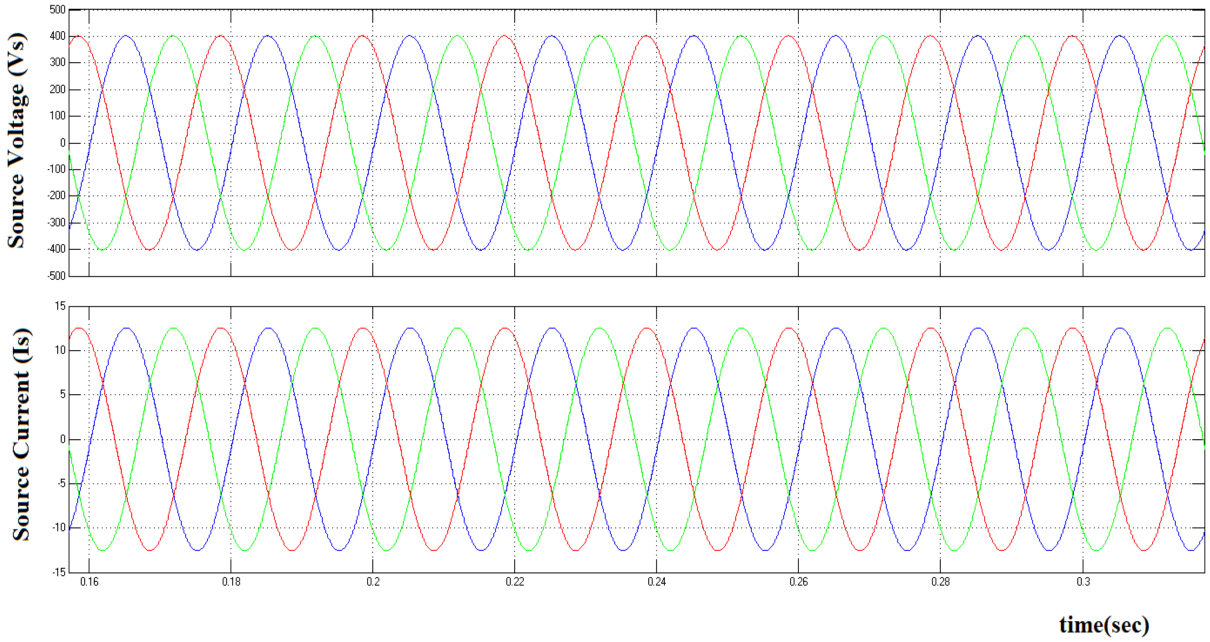
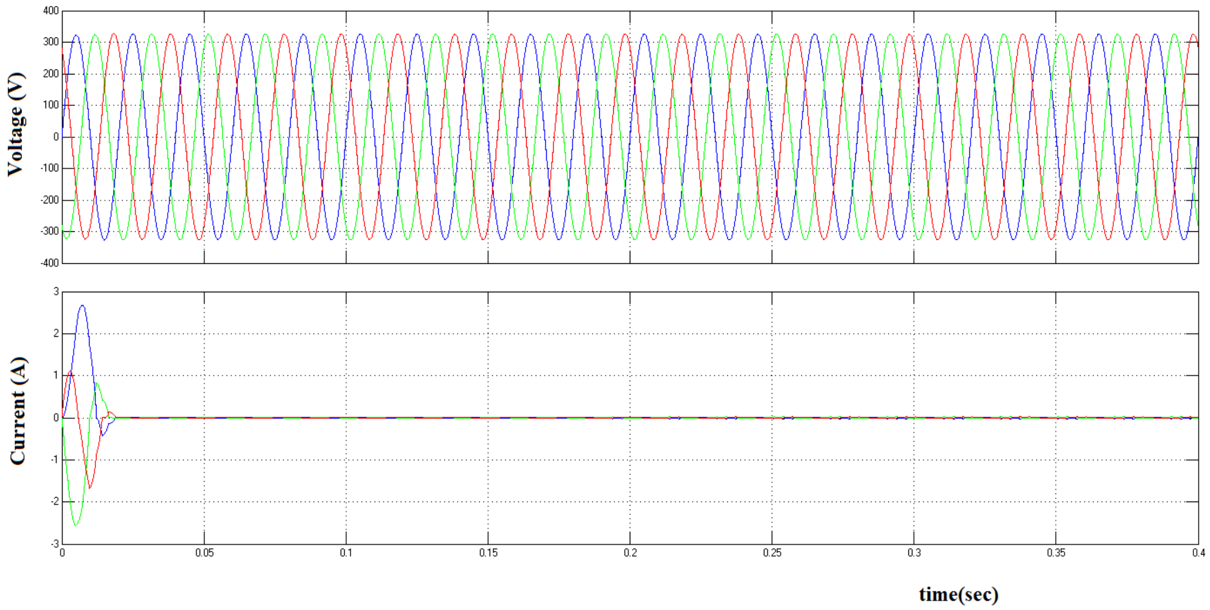


Feeder-1 Output Voltage & Current Waveform



Feeder-2 Output Voltage & Current Waveform

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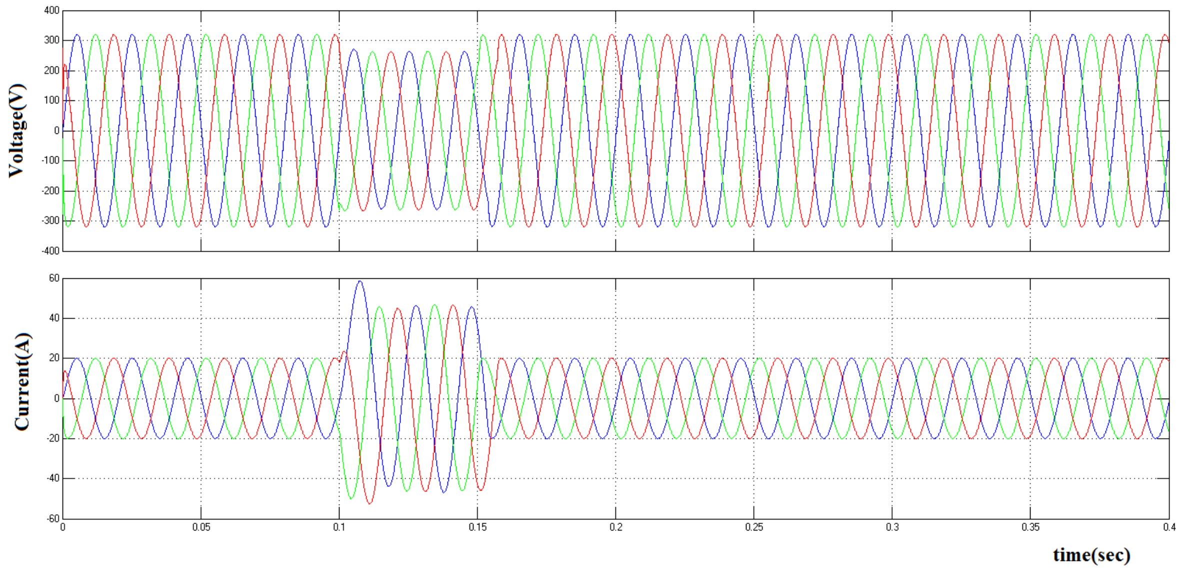
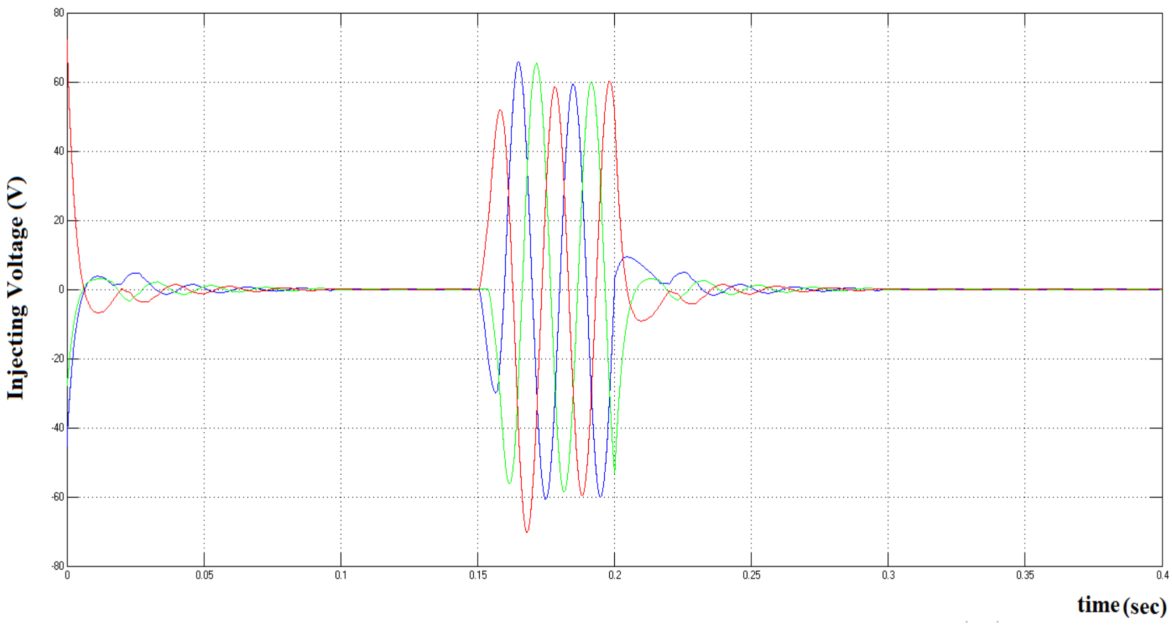


Injected DVR Voltage Waveform



Feeder-1 & Feeder-2 Displacement Factor Measurement

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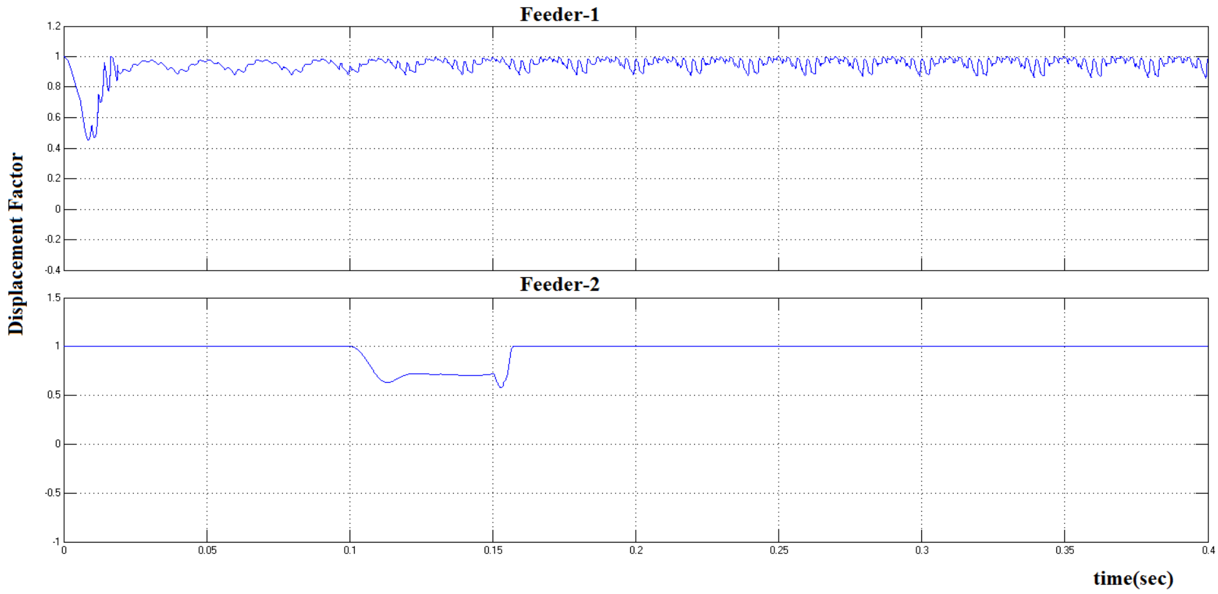
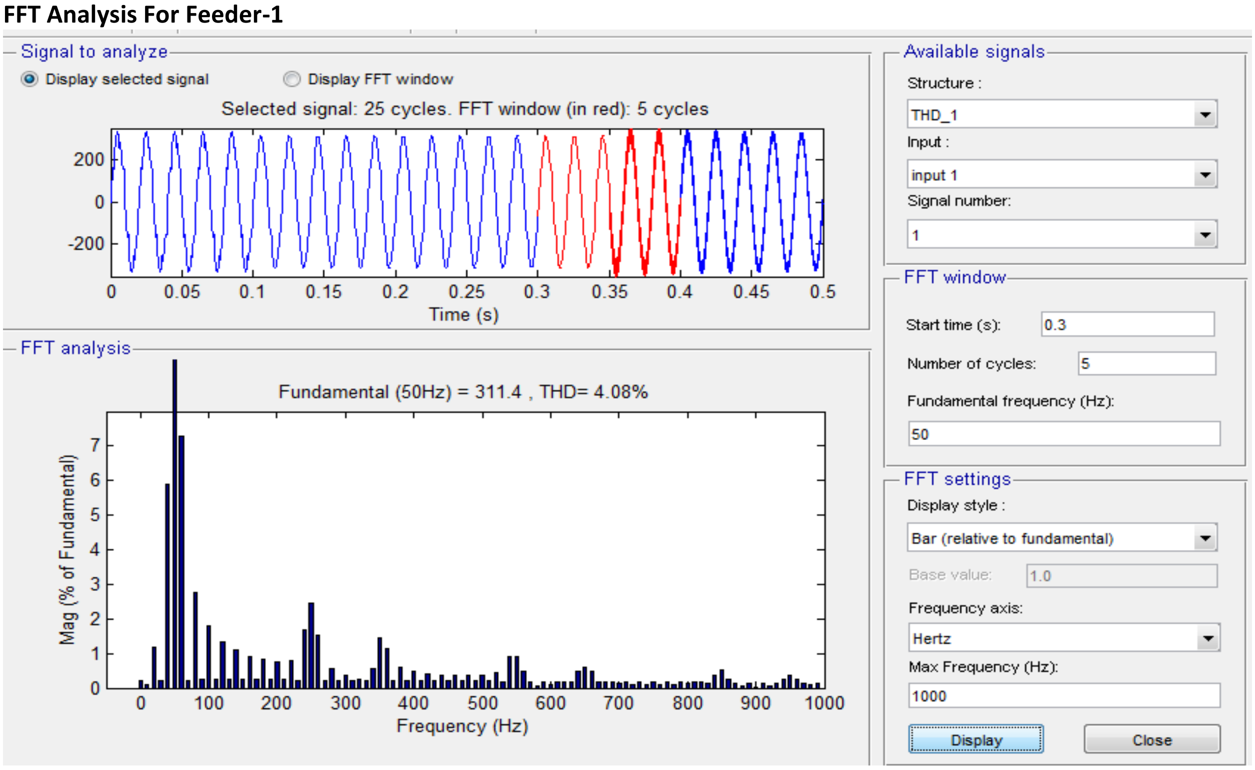


Figure 5 simulation Results

FFT Analysis For Feeder-1



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FFT Analysis For Feeder-2

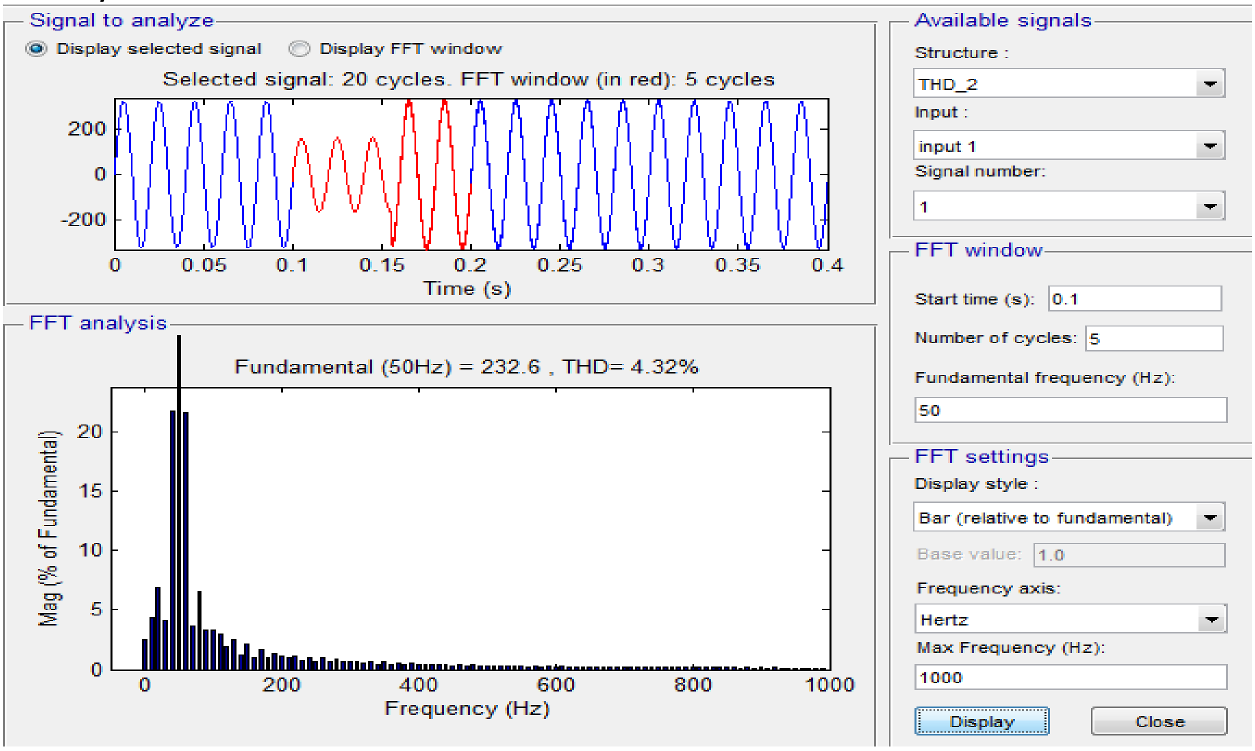

Figure 6 FFT waveform

IV. CONCLUSION

This paper proposes a new operational mode for the IDVR to improve the DF of different feeders under normal operation. In this mode, the DF of one of the feeders is improved via active and reactive power exchange (PQ sharing) between feeders through the common dc link. The same system can also be used under abnormal conditions for voltage sag/swell mitigation. The main conclusions of this work can be summarized as follows: 1) Under PQ sharing mode, the injected voltage in any feeder does not affect its load voltage/current magnitude, however, it affects the DFs of both sourcing and receiving feeders. The DF of the sourcing feeder increases while the DF of the receiving feeder decreases. 2) When applying the proposed concept, some constraints should be satisfied to maintain the DF of both sourcing and receiving feeders within acceptable limits imposed by the utility companies. These operational constraints have been identified and considered. 3) The proposed mode is highly beneficial if the active power rating of the receiving feeder is higher than the sourcing feeder. In this case, the DF of the sourcing feeder will have a notable improvement with only a slight variation in DF of the receiving feeder. The proposed concept has been supported with simulation and experimental results.

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